mem. 01

DOC. NO. 67
TOTAL PAGES 6
COPY 2 OF 4

16 October 1959

Dear Ed,

Enclosed herewith is a preliminary analysis of the problem of bay environment. The indicated tolerances on pressure and temperature are quite nasty but, when real gas behavior is used to determine functional relationship of pressure and temperature, then the tolerances will probably become less stringent. I think it would be worthwhile if someone of your people could make an analytic approximation of the functional relationship to be expected between bay temperature and pressure. We are also working on this problem.

Also enclosed are revisions to drawings 546-0900 and 546-0901 which reflect our present understanding of the tabulated characteristics. We will attempt to keep these up to date as new information and changes become available. You can use the duplicate set of drawings to "red line" for our information any misunderstanding we may have.

We are at work on both a smaller system and a relocation of the 24" system farther aft. I hope to have new drawings to you within a week.

Best regards

Milt

Milt

MBR:mb

enc: 3

cc: LKW
RMS

The dependence of optical index on gas density is given quite accurately[1] by

$$(n-1) = \frac{\rho}{\rho_o}\,(n_o-1)$$

where n = index of refraction, and

ρ = density.

It is also known[2] that

$$\frac{\rho}{\rho_o} = \left(\frac{P}{760}\right)\left(\frac{273}{T}\right)$$

for a constant volume, where

P = Pressure in mm. of Hg

T = Temperature in $^{\circ}$K.

Consequently, we can express the dependence of index on pressure and temperature by

$$(n-1) = \left(\frac{P}{760}\right)\left(\frac{273}{T}\right)(n_o-1).$$

For $\lambda = .6\mu$, $n_o - 1 = 2.92 \times 10^{-4}$, when $P = 760$ mm., $T = 273\ ^{\circ}$K. So,

$$(n-1) = 1.05 \times 10^{-4}\,\frac{P}{T},$$

and therefore

$$\frac{\partial n}{\partial P} = \frac{1.05 \times 10^{-4}}{T} \text{ per mm. Hg}$$

$$\frac{\partial n}{\partial T} = -\,1.05 \times 10^{-4}\,\frac{P}{T^2} \text{ per } ^{\circ}\text{K}.$$

---

1 - Jenkins & White, "Fundamentals of Optics" 2nd Ed., page 251

2 - American Institute of Physics Handbook, page 3-56

Thus we arrive at the following table:

Condition / Variant	$P = 1/3$ atm $= 250$ mm		$P = 1/10$ atm $= 75$ mm	
	$T = 110°F = 316°K$	$T = 130°F = 328°K$	$T = 110°F = 316°K$	$T = 130°F = 328°K$
$\frac{\partial n}{\partial P}$ (per mm Hg)	3.3×10^{-7}	3.2×10^{-7}	3.3×10^{-7}	3.2×10^{-7}
$-\frac{\partial n}{\partial T}$ (per °K)	2.6×10^{-7}	2.4×10^{-7}	7.8×10^{-8}	7.2×10^{-8}

Furthermore

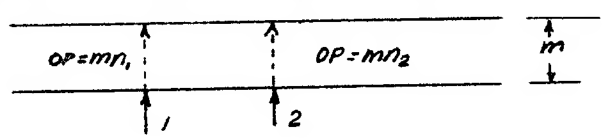
$$\Delta n = \frac{\partial n}{\partial P}\Delta P + \frac{\partial n}{\partial T}\Delta T$$

$$= \left(\frac{\partial n}{\partial P}\frac{\partial P}{\partial T} + \frac{\partial n}{\partial T}\right)\Delta T$$

$$= \left(\frac{\partial n}{\partial P} + \frac{\partial n}{\partial T}\frac{\partial T}{\partial P}\right)\Delta P ,$$

and the last two expressions allow calculation of Δn as a function of either ΔT or ΔP alone, providing the functional relation of P and T is known.

Now, consider two light beams passing through a gas layer m meters



thick. The optical path difference is $(mn_1 - mn_2)$ or $m\Delta n$. This difference must everywhere be less than about $1/20\lambda$ where λ = wavelength of light.

If we assume m = 0.1 meter,

$$\frac{\lambda}{20m} = \frac{.6 \times 10^{-6}}{20 \times .1} \doteq 3 \times 10^{-7}.$$

Consequently $\Delta n \leq 3 \times 10^{-7}$ is required, and this is nearly achieved when

$\Delta P \leq 1$ mm Hg (T = Constant)

$\Delta T \leq 1°K$ (P = 1/3 atm)

$\Delta T \leq 3°K$ (P = 1/10 atm)

It can also be achieved in wider limits of either ΔP or ΔT provided $\frac{\partial P}{\partial T} > 0$ since $\frac{\partial n}{\partial P} > 0$ and $\frac{\partial n}{\partial T} < 0$. That is, if increasing pressure is accompanied by increasing temperature (or both decreasing), then Δn is reduced. For a Boyle's Law gas, at least, $\frac{\partial P}{\partial T} > 0$ always.

MDR
13 Oct.'59

QUANTITY	AMOUNT	STATUS	REFERENCE
SIZE OF BAY FOR EQUIP.	CONE 44.8"-52.6" ID x 57" LG.	PRELIMINARY	"Q" BAY DWG. DTD 10-1-59
SIZE OF HATCH	TRAPEZOID 34.5"-38.24" x 61"	PRELIMINARY	"Q" BAY DWG. DTD 10-1-59
WINDOW SEAM WIDTH	2" MIN. STRUCTURE	FIRM	VEH. 0811
ALTITUDE PROFILE (CRUISE)	± 7.3% ABOUT NOM.	PRELIMINARY	DWG "MISSION CURVE"
VELOCITY	± 100 KNOTS ABOUT NOM	FIRM	DWG "$\frac{V}{H}$ CRUISE RANGE"
DRIFT VELOCITY	100 KNOTS	ESTIMATE	VERBAL AT MTG. 18 AUG. 59
ANGLE OF ATTACK	$6\frac{1}{2}° - 7\frac{1}{2}°$	(PRETTY FIRM)	" " " " " "
SKIN TEMP. PROFILE (T.O. - LNDG)	SEE SKETCH 546-0902	TO BE MADE MORE ACCURATE	" " " " " "
BAY ENVIRONMENT TEMP. PRESS. HUMID.	35°-150°F 5.00 PSIA 60°F DEW POINT	MAY CONFLICT WITH CONTENTS	VEH 0917 & VERBAL AT MTG 13 OCT 59
ELEC. PWR. AVAIL.	28 V. DC. ± 0.3V 40 AMPS NO DROPOUT	PRELIMINARY	VEH 0917 VERBAL AT MTG 13 OCT 59
ELEC INTERFERENCE RADIAT. CONDUCT.	NO PROBLEM ABOVE AVERAGE	PRELIMINARY	VERBAL AT MTG 13 OCT 59
NADIR SIGNAL	AVAILABLE TO WITHIN $\frac{1}{2}°$	ESTIMATE	VERBAL AT MTG 2 JUN 59
LINEAR MOTION (AMPL VS FREQ.) VERTICAL LONGIT LATERAL	LESS THAN .05 G	ESTIMATE	VERBAL AT MTG. 18 AUG 59
STRUCTURAL DESIGN LIMITS (CASED) VERTICAL LONGIT. LATERAL	+3, -1 G ± 1.5 G ± 2.0 G	PRELIMINARY	VERBAL AT MTG 13 OCT 59
ULTIMATE LIMIT	1.5 x DESIGN	FIRM	VERBAL AT MTG 3 JUN 59
CRASH TIE DOWN	10 G	PRELIMINARY	VERBAL AT MTG. 13 OCT 59
ANGULAR MOTION (AMPL. VS. FREQ.) PITCH ROLL YAW	±1° ±5° ±1°	PRELIMINARY	VERBAL AT MTG 18 AUG 59
CRUISE STABILITY (RAD/SEC²) PITCH ROLL YAW	?	DATA TO BE PROVIDED	VERBAL AT MTG. 13 OCT 59
ENGINE R.P.M.	7400 ± 100	FIRM	VEH 0917
COOLING AIR	~ 35°F 1 LB/MIN 5 PSIA -60°F DEW POINT	PRELIMINARY	VERBAL AT MTG'S 18 AUG 59 & 13 OCT 59
SURFACE MISMATCH RECESSION	{.005 AFT FACING 0 FWD FACING} LOFTING REQUIRED	PRELIMINARY	VEH 0917
MANOUVER VELOCITY	1°/SEC MAX 10°/SEC MAX 1° SEC MAX	PRELIMINARY	VERBAL AT MTG'S 18 AUG 59 & 13 OCT. 59

TABULATED VEHICLE CHARACTERISTICS

DWG. NO. 546-0900 12 OCT 59

REV A 16 OCT 59

QUANTITY	AMOUNT	STATUS	REFERENCE
WEIGHT	1200 POUNDS	ESTIMATE	VERBAL AT MTG. 13 OCT 59
LAYOUT	24" LG × 25" HIGH × 35" WIDE WITHOUT PAPER & ELECTRONICS	PRELIMINARY	DWG 546-0029
ENVIRONMENT TEMP PRESS HUMID	100°-140°F, ± ? ? BELOW DEW POINT	SUBJECT TO FURTHER CALCULATION & DISCUSSION	VERBAL AT MTG 18 AUG 59
WINDOW SIZE	1 - 10.5 × 18 1 - 10.5 × 20	PRELIMINARY	SKETCH 546-0903
WINDOW LOCATION	STA 344 - 367	PRELIMINARY & MAY BE MOVED AFT	SKETCH 546-0903
POWER REQUIRED (EXCLUSIVE OF WINDOWS)	28 V.D.C. ± 1 1 KW PEAK (1 SEC) 0.5 KW AVG.	ESTIMATE	VERBAL AT MTG 13 OCT 59

TABULATED MOONSHINE CHARACTERISTICS
DWG NO. 546-0901 12 OCT 59
Rev A 16 Oct 59 MDR